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RIPARIAN AREA MANAGEMENT

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Riparian and Wetland Classification Review

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RIPARIAN AREA MANAGEMENT

Riparian and Wetland Classification Review

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Riparian and Wetland Classification Review

I. Introduction

In recent years a large number of riparian and wetland classification and description procedures have been developed and/or modified by many investigators. Riparian and wetland managers have seen this myriad of procedures and basically have been confused about which one to use and what they are supposed to do. The following riparian and wetland classification and description procedures were selected for review from a very lengthy list because they have one or more of the following characteristics: they are regional or national in scope; they provide management information; and they integrate stream attributes and riparian vegetation.

1. SCS-BLM Standard Ecological Site Description.
2. Southwestern Wetlands — Their Classification and Characterization.
3. The Canadian Wetland Classification System.
4. Riparian Zone Associations of the Deschutes, Ochoco, Fremont, and Winema National Forests.
5. Classification and Management of Riparian and Wetland Sites in Montana.
6. Classifying Rangeland Riparian Areas: The Nevada Task Force Approach.
7. Classification of Riverine Riparian Habitats for Management of Fisheries Resources.
8. An Ecological Characterization of Rocky Mountain Montane and Subalpine Wetlands.
9. Ecosystem Classification Handbook.
10. Classification of Wetlands and Deepwater Habitats of the United States.
11. Riparian Community Type Classification of Eastern Idaho-Western Wyoming.

II. Purpose

It is the policy of the Bureau of Land Management (BLM) to apply the Standard Ecological Site Description procedure patterned after the Soil Conservation Service (SCS) Range Site procedure and expanded by the BLM (USDA-SCS 1976, USDI-BLM 1990) to grazable woodland, native pasture, and riparian sites. However, other classification and description procedures exist and often must be used to make use of all available information or to coordinate between other agencies and institutions during riparian and wetland inventory. This document introduces major concepts relevant to the understanding of riparian systems and reviews selected riparian and wetland classification and description procedures. This document also provides a means of relating the various procedures. Appendix A contains a crosswalk of those reviewed classification and description procedures that can be readily applied to riparian site descriptions and concepts of vegetation succession and site progression discussed below. Appendixes B-E provide information and define terminology that should help in understanding and applying classification and description procedures.

III. Vegetation Succession and Site Progression

Succession usually represents an orderly progression (except in cases of fire, etc.) of plant community change, towards a relatively stable state often termed the "potential natural community" (PNC) or "potential plant community" (PPC). These changes in plant communities may also accompany important refinements in certain environmental characteristics, such

as physical properties (e.g., organic material in the soil), soil chemistry, soil moisture, understory solar radiation, root distribution, populations of insects and animals, and appearance. These changes are often made possible through the behavior of the site's environment (particularly soil and water). The ability to discern these environmental factors from one site to another is a basis for ecological classification. Often, the plant community is used as an indicator of these integrated environmental factors.

Currently, the most frequently used procedure of classifying community ecology follows the concepts introduced by Daubenmire (1959). Many recent authors have used these concepts in their work with riparian and wetland environments (Youngblood et al. 1985, Kovalchik 1987, Hansen et al. 1988, Hansen 1989, Szaro 1989). These authors demonstrate that the concepts of succession used in upland environments are equally applicable to riparian systems, although the riparian site is generally much more dynamic. It is useful in further comparison and discussion to review some of the basic terminology and concepts applied in these recent documents:

> Association - In normal usage, an association is a climax community type or potential plant community. In riparian systems, because of their dynamic nature, a true climax community may not have an opportunity to occur (Youngblood et al. 1985). An association for a riparian environment is therefore a plant community type representing the latest successional stage attainable on a specific hydrologically influenced surface (Kovalchik 1987, Hansen 1989). Hansen (1989) uses the term "riparian association" while Youngblood et al. (1985) chose the term "potential stable community type" that approaches an association.
>
> Community Type - This is defined as an aggregation of all plant communities in some procedures, or as existing/dominant plant communities in others. Community types are distinguished by floristic and structural similarities in both overstory and undergrowth layers. Community types are considered to represent seral stages.
>
> Site Type - This is the area of land occupied or potentially occupied by a specific association. Site types that were the same would have similar environments that could develop the same potential plant community. Hansen (1989) uses the term "riparian site type" when describing a site capable of producing a "riparian association."

Figure 1 offers two similar views of successional concepts. Hansen (1989) provided an illustration, shown in part a of Figure 1, to depict the relationship between site type, community type, and association.

The illustration shows that community types are seral to associations (potential natural communities) and that some community types are common to one or more associations. It also shows that one site type (range type in part b of Figure 1) supports one association (PNC).

In many riparian systems there is a high potential for physical environments to undergo sudden and/or extreme changes because of the potential for soil erosion, deposition, and changes in water availability. Youngblood et al. (1985) stated "Directional processes from one community type to another indicate succession; we have not attempted to indicate the

many possible relationships resulting from retrogression." This acknowledges succession and the complexity of possible community types due to site change. To help emphasize that these changes are the rule rather than the exception in riparian environments, we have introduced the term "site progression" which denotes major changes in the site. Site progression is not intended to diminish or replace any of the concepts of community succession; rather, it is a term to help those less familiar with the dynamics of riparian systems focus on the expectation for site change. Generally, site progression can be thought of as a site change which may result in a different potential natural community for the site. An example of this would be a site located on a flood plain consisting of fine substrate that undergoes extreme incisement, eventually changing the site from a moist to a very dry environment. The site progression is also seen in the succession of a gravel bar to an eventual nonflooded, cottonwood dominated terrace. In Figure 1, site progression would be seen as a site change between columns of the site types (riparian and/or habitat types) or cones. Figure 2 is a representation of site progression.

Additionally, for a classification or site description to be very useful to management it should recognize and discuss site succession, site progression, and site potential and what makes them occur, thereby offering managers a means for rational management.

> "It is important to remember that not all the landscape is at its potential. In fact, only relatively small amounts are. However, by knowing what the potential is, a manager can understand the processes and how to best manage for them." (Paul Hansen, pers. commun.)

We refer to this as an understanding of "process pathways." Once the process pathways are recognized, management can better understand cause and effect relationships.

IV. Riparian Health and Ecological Site Status

Riparian health has been related to ecological site status in recent years. This is a dangerous and functionally impossible view of how riparian systems operate. The following paragraphs discuss the concepts of ecological site status and riparian health in hopes that a more clear understanding of riparian system function will result.

Ecological site status refers to the position on a successional pathway that a particular site may be in. For example, a newly vegetated gravel bar may be covered with pioneering plant species such as cottonwood and willow. This site is said to be in early seral stage because it is at the beginning of its successional pathway. It is also in a frequently flooded state, allowing deposition interspersed with scoured flow patterns. As vegetation succession occurs and aggradation continues, young cottonwood trees may dominate an understory adapted to frequent or occasional flooding. As long as the relationship with flooding frequency and timing is maintained to allow cottonwood regeneration (not allowing the young cottonwoods to effectively trap sediments or become older), vegetation succession cannot proceed and could be considered in an advanced stage for that particular set of physical circumstances. However, if aggradation has occurred far enough (which may be directly related to the presence of the cottonwoods) or stream channel migration relegates the site to a rarely flooded or nonflooded state, the cottonwoods may persist to a decadent stand. Regardless of the longevity of the cottonwoods at this location, site progression has evolved to a new state allowing vegetation succession to proceed to a new potential dominated by ash or perhaps

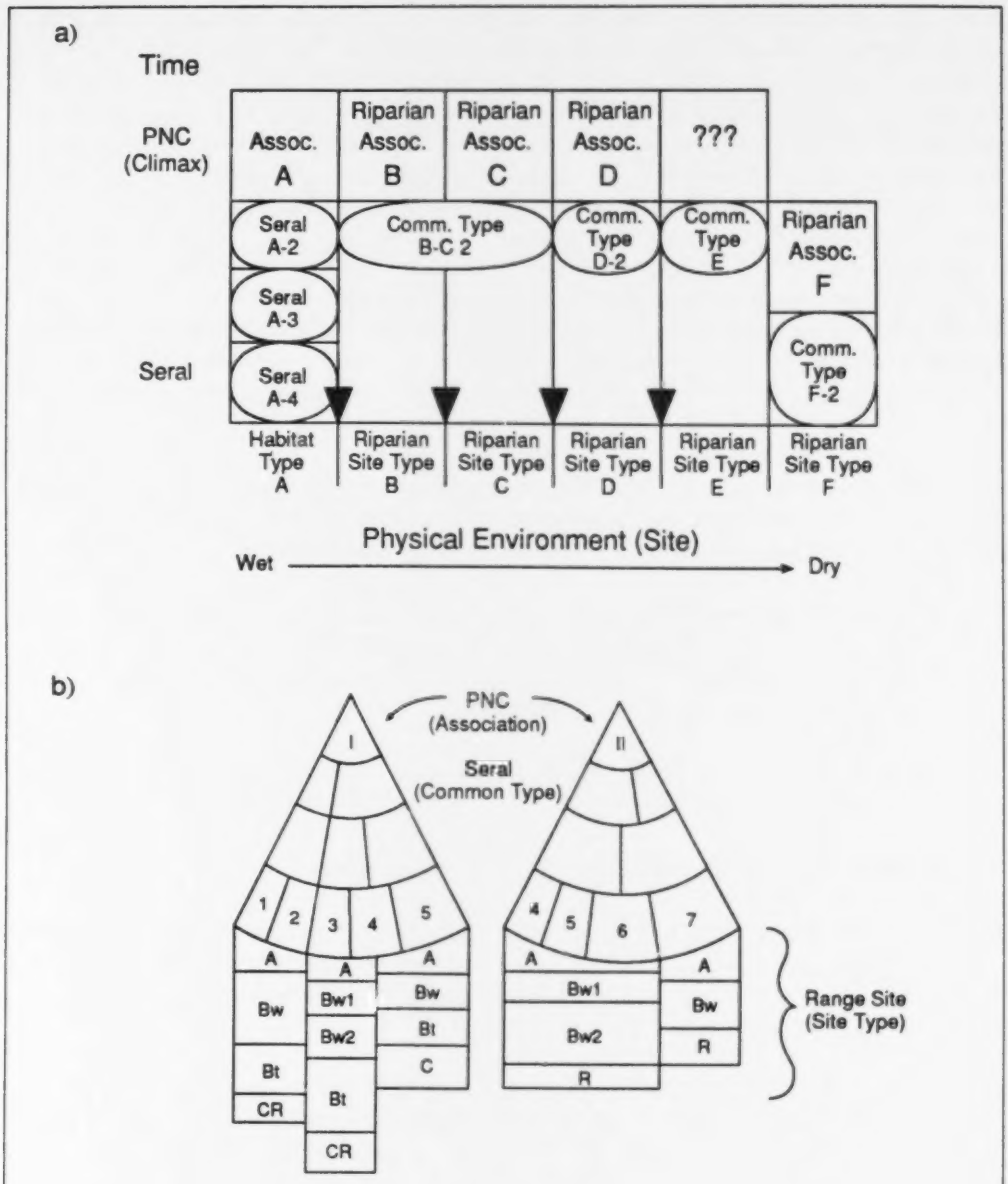

Figure 1. Comparison of Two Successional Models. a) Illustration of classification terminology as it relates to time and the physical environment (site) for riparian areas, after Hansen (1989). b) Conceptual "cone" model of secondary successional plant communities developed by Huschle and Hironaka, and Neiman, Jr. and Hironaka, modified to illustrate terms as shown in "a" above, and those typically used within range site descriptions. Depicted are two range sites, seral plant communities, and range site specific soil units. Note seral plant communities 4 and 5 can occur in two sites having different potential natural communities (potential plant communities).

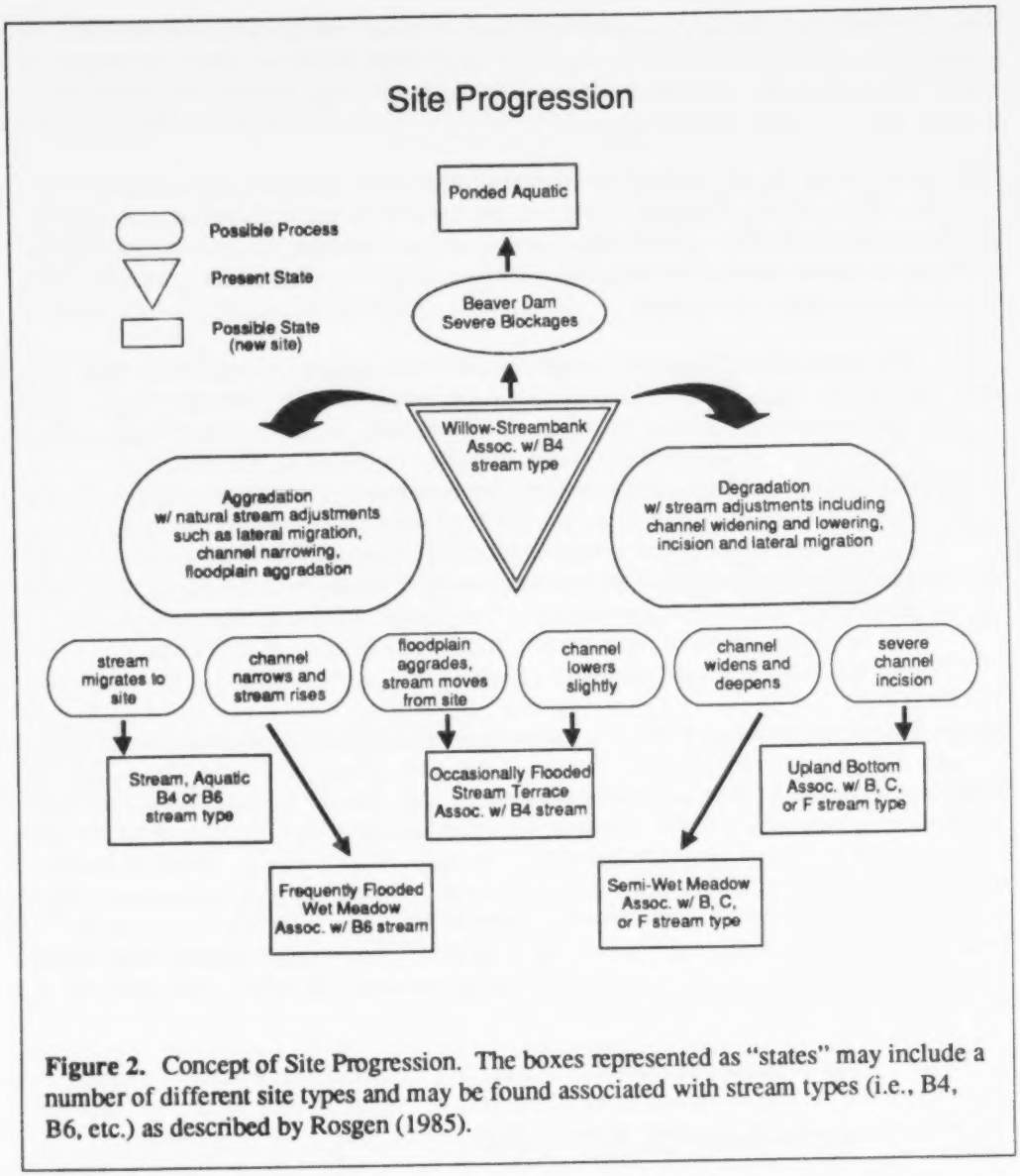
Site Progression
Possible Process
Present State
Possible State (new site)
Ponded Aquatic
Beaver Dam Severe Blockages
Willow-Streambank Assoc. w/ B4 stream type
Aggradation w/ natural stream adjustments such as lateral migration, channel narrowing, floodplain aggradation
Degradation w/ stream adjustments including channel widening and lowering, incision and lateral migration
stream migrates to site
channel narrows and stream rises
floodplain aggrades, stream moves from site
channel lowers slightly
channel widens and deepens
severe channel incision
Stream, Aquatic B4 or B6 stream type
Occasionally Flooded Stream Terrace Assoc. w/ B4 stream
Upland Bottom Assoc. w/ B, C, or F stream type
Frequently Flooded Wet Meadow Assoc. w/ B6 stream
Semi-Wet Meadow Assoc. w/ B, C, or F stream type

Figure 2. Concept of Site Progression. The boxes represented as "states" may include a number of different site types and may be found associated with stream types (i.e., B4, B6, etc.) as described by Rosgen (1985).

other self-perpetuating species. The decadent cottonwood stand is now an early successional stage to a different potential natural community. Vegetation succession may or may not be allowed to proceed long enough to reach that new potential, depending on stream dynamics and hydrology in relation to the valley bottom morphology.

Since riparian systems are dynamic, some may never be able to attain a climax community, or at least not attain it without long term evolution of existing valley bottom morphology. A stream flood plain developing within the walls of a past incisement provides such an example. The soil-water-plant relationships within the developing flood plain may provide the same wet meadow/meadow complex of site potentials as found elsewhere. The stream channel may be aggrading at approximately the same rate as the adjacent flood plain. Site progression, in this case, is actually increasing the aerial extent of the riparian vegetation (and associated ground water) as the system aggrades. The system is in an excellent functional

state. However, the forming and reforming of plant communities due to the increased frequency of deposited sediments limits vegetation succession to early and mid-successional status. This will be the case until the geomorphic processes of aggradation slow sufficiently to allow vegetation succession to proceed.

Riparian health must be viewed with the understanding that the riparian system is inherently dynamic. The condition (abundance, vigor) of the vegetation on a site would be only one attribute of riparian health. The riparian health should be evaluated in terms of physical and biological function in relation to the *entire watershed.* The following excerpts from Gebhardt et al. (1990) introduce this concept:

> "The interaction of watershed characteristics and vegetation can be described in terms of physical and biological processes and factors. Such processes and factors can be grouped by physical and biological characteristics. The U.S. Fish and Wildlife Service (1989) identified the major vegetal biological characteristics or responses as survival-maintenance, recruitment-reproduction, and community dynamics. The major physical characteristics follow the watershed characteristics described above grouped as moisture/inundation (water quantity), physical and chemical water quality, transport/deposition, and channel/floodplain geometry. Our responsibility is to understand their importance to the riparian system, particularly in terms of their rates, magnitude or extent, and duration."

The processes and associated factors controlling riparian function are listed in Appendix F.

Riparian health should not be confused with ecological site status. A young site or an old site can be in good health, as with any organism. However, one should not assume that a stream in an advanced ecological condition is desirable (or even attainable) in all instances. Some sites, for example, may be at an early or mid-seral ecological status and provide wonderful waterfowl habitat. Provided these sites are in good health, they are serving a very positive function. Another example might be a willow-dominated PNC supporting a trout population. At the PPC and in excellent health, such a site might produce an abundant fish population, but the vegetation density would preclude fishing.

In summary, riparian health and ecological site status are two different characteristics of riparian systems. A site in any ecological status may be in good or poor health. All sites should not necessarily be managed for late seral condition, particularly if it precludes a desired function or beneficial use. Riparian health should be judged on the functions that it provides compared to functions that should be present in relation to the entire watershed. All riparian systems should not be expected to have identical functions.

V. Review Format

Each classification and description procedure included in this technical reference is described and discussed using the following standard format:

Name: Name of the classification or description procedure.

Authors: Authors and/or agencies preparing the procedure.

References: Documents that explain the procedure.

Objectives: Describes the major objectives of the system or procedure as given or estimates the objectives based on contents of the reference.

Designed Users: Estimates likely users of the system.

Area of Applicability: Region, state, or locality where the procedure appears or is proven to be able to work. No discussion on scale is given. The procedures described can be used at about any scale. The size of the areas depicted in the classification will be dependent on the purpose of the classification which will define the detail of the mapping units and the sorting process used to aggregate and separate.

Classification Units, Description, and Data: Units or major contents or data requirements of the classification are given in order of a hierarchical structure, where given, otherwise they will be placed based on the best estimate of the reviewer.

Use, Testing, Validation: Information on use is given, particularly in reference to large-scale testing or validation efforts.

Ease of Application: An estimate is given on how easily the procedure could be applied by professional land resource specialists.

Use in Defining System Response and Potential: System response is the response of a riparian or wetland to various environmental change. Potential refers to the potential natural community as described above. Classification and description procedures may simply provide a method of categorization without regards to environmental response. However, without some ability to define the response and potential, a classification procedure cannot relate to management very effectively. Ties to system response might include both physical and biological factors providing clues to a system's limiting factors such as soil-water regime, substrate, riparian-riverine interaction, channel morphology, flora, and fauna.

Use in Determining State of System: A discussion is included on the procedures handling of succession and site progression, the concepts of which are explained above.

Relation to Other Procedures: Well-known procedures or standards are given if they are known to have been used in the development.

Automated Data Processing (ADP): Where ADP applications have been built for the procedure, they are mentioned.

Limitations and Assumptions: Perceived limitations in accomplishing objectives are given. Assumptions inherent in the procedure are given if they are considered significant.

VI. Classification and Description Procedures

1. Name: SCS-BLM Standard Ecological Site Description.

Authors: Soil Conservation Service, Bureau of Land Management.

References: U.S. Department of Agriculture. 1976. National Range Handbook, as amended. Soil Conservation Service, Washington, DC.

U.S. Department of Interior. 1990. National range handbook. BLM Manual Handbook H-4410-1. Bureau of Land Management, Washington, DC.

Objectives: The National Range Handbook (SCS) as supplemented by BLM Manual Handbook H-4410-1 National Range Handbook includes procedures for preparing standardized ecological site (range site) descriptions. The National Range Handbook provides for range site descriptions that include a unique name, physiographic features, climatic features, vegetation ecology and production, soils, and management interpretations (which can be used in making management recommendations). BLM Manual Handbook H-4410-1 further provides that the concept also applies to grazable woodlands, forest and riparian/wetland sites.

Early in 1988, BLM determined that the standard site description procedures contained in the National Range Handbook as applied to uplands would accommodate land features associated with riparian and wetland sites as well. These procedures were modified by adding riparian and wetland associated water features and additional descriptions of site dynamics to the standard site description format and the Siteform program.

Designed Users: All levels of land users.

Area of Applicability: Universal application to rangeland, woodland, and native pasture.

Classification Units, Description, and Data:

Classification Units	Description
Physiographic Features	Occurrence of the site in the landscape. Degree and direction of slopes. Range of elevation.
Climatic Features	Range in average annual precipitation, temperature, and seasonal distribution. Average beginning and ending dates of growing season for major native forage species.
	Other features such as storm intensity, wind velocity, and drought cycles that typify the site and may contribute to or limit its potential.
Vegetation Ecology	Description of the plant community that would become established if all successional sequences were completed without major disturbance under similar environmental conditions (assuming no major site changes such as seen

	with site progression). Concepts of potential plant community, seral ecological status, and seral community apply to this procedure.
	List of major plant species and their normal relative proportion in the total natural plant community.
	Other features, if deemed significant, such as ground cover, plant spacing, and overstory canopy. Descriptions of additional communities that may occur on the site under various stress and/or at different successional stages.
	Estimated total annual production and range in favorable and unfavorable years.
Soils	Briefly describes the main properties of the major soils associated with the site with special significance on important soil-vegetation-water properties.
	Name of major soils and their respective phase associated with the site.
Associated Water Features	Includes information on the morphology and hydrology of associated water system. Typical attributes include stream type (Rosgen 1985), flow regime, erosional/depositional features, surface and ground water features.
Site Interpretation	Information on potential importance of the site for each of its major uses. Includes successional stages and potential to change characteristics (stability) or to change states.
Identification Authentication	Gives location of typical example of the site. Identifies site with the Major Land Resource Areas (MLRA) in which it occurs. Gives information of when the description was approved and the principal author and agency.

Use, Testing, Validation: The procedure in the National Range Handbook is used worldwide to prepare site descriptions for rangelands. These procedures have been modified, tested, and validated for use in preparing site descriptions for riparian areas. Procedures for site correlation exist and are compatible with the National Soil Handbook.

Ease of Application: Ease of application depends on the ability and experience of the users. A team of specialists consisting of a biologist, botanist/ecologist, soil scientist, and hydrologist is required to use these procedures on riparian and wetland sites. The procedures for mapping, delineating, describing, and interpreting sites have been used by several agencies for several years. Sufficient training, review, and correlation is key to the success of the procedure.

Use in Defining System Response and Potential: A major purpose of the procedure is to define community response and the reasons why a particular response occurs.

Use in Determining State of System: The procedure is well suited to identify changes of state and the reasons for site progression (aggradation/degradation).

Relation to Other Procedures: The procedure makes use of other nationally or internationally recognized procedures, such as the National Soil Handbook. It is conceptually similar to others in recognizing a potential or climax plant community and successional stages or communities.

Automated Data Processing: Several levels of data processing assistance are available for the procedure.

Limitations and Assumptions: Use of this procedure is limited by the extent of knowledge of similar sites and by the expertise of the users. Experienced personnel are required to correctly identify site potential. The end product of the procedure is a very useful document for management.

2. Name: Southwestern Wetlands — Their Classification and Characterization.

Authors: David E. Brown.

References: Brown, D.E. 1978. Southwestern wetlands — their classification and characterization. *in*: Proceedings of the National Riparian Ecosystems Symposium, Callaway Gardens, Georgia, Dec. 11-13, 1978. pp. 269-282.

Brown, D.E. and C.H. Lowe. 1973. A proposed classification for natural and potential vegetation in the Southwest with particular reference to Arizona. Ariz. Game and Fish Dep., Fed. Aid Proj. Rpt. W-53-R-22 WP-4JI:1-26.

Objectives: Provide a hierarchical structure for the world's biotic communities based on those factors most important in the evolution of origin, structure, and composition of all ecosystems, both wetland and terrestrial. Recognizes plant components within an assigned ecological distribution and could lead to the species of wildlife expected to be present.

Designed Users: Ecologists, wildlife biologists, zoologists.

Area of Applicability: Everywhere.

Classification Units, Description, and Data:

Classification Units	Description
Biogeographic Realm	Geographic and biologic origin-evolutionary boundaries. Generally very large with the exception of small areas showing high degree of endemism. Seven realms are used: Nearctic (Continental North America exclusive of the tropics and most highland areas south of the Tropic of Cancer); Palaearctic (Eurasia exclusive of the tropics); Neotropical and Antarctican; Oriental; Ethiopian; Australian; Oceanic.
Vegetation	Classed as either upland wetland, or in the case of altered lands, cultivated. All existing and potential natural vegetation are placed in these classes.
Formation Type	Refers to recognized ecological formations (biome interpretation types). Wetland formation types include wet tundra, forest, swampscrub, marshland, strand (unvegetated bank or shore), and submergent.
Climate Zone	Refers to one of four world climate zones (arctic boreal, cold temperate, warm temperate, tropical-subtropical).
Regional Formation	Refers to a subcontinental unit that is a major biotic community (biome) usually centered in but not restricted to a biogeographic region or province possessing a particular precipitation pattern or other climatic regime.

Series	Provides the principal or plant-animal communities within general biomes, recognized and distinguished primarily on distinctive climax plant dominants. These series sometimes referred to as cover types or vegetation types are each composed of one or more biotic associations characterized by shared climax dominants—within the same formation, zone, and biome.
Association	Refers to distinctive plant associations based on the occurrence of particular dominant species more or less local (or regional) in distribution and generally equivalent to habitat types as outlined by Daubenmire and Daubenmire (1968), Layser (1974), and Pfister et al. (1977).
Composition-Structure-Phase	Is a qualitative description of the structure composition, density for the dominants. Most detailed.

Use, Testing, Validation: The reference for this classification system is preceded by many other references (Brown 1973; Brown and Lowe 1973; Brown and Lowe 1974a, b; Brown, Lowe, and Pase 1977) to the extent it should be considered well tested. There was little information sought on its use; however, it is assumed to be in use in the Southwest.

Ease of Application: Half of the categories are developed from existing information. Field work is necessary to classify below the series level and also would be required at the series level in areas where vegetation is not generally identified.

Use in Defining System Response and Potential: The hierarchy of the procedure allows for very general climatic consideration and general animal habitat consideration. The procedure does not deal with geomorphic processes or riverine environments. However, this information could be incorporated easily.

Use in Determining State of System: The state of the system appears inherent at the association level in this procedure. The state of a system in regards to site succession and site progression may be identified, but is not recognized as a part of the procedure.

Relation to Other Procedures: This procedure has placed reliance on existing classification procedures for zoogeography, world climates, wetland determination [through SCS hydric procedures (assumed but not stated in document), world vegetation-habitat zones, and finally successional vegetation procedures of Daubenmire creation].

Automated Data Processing: The procedure was set up in a numeric fashion to facilitate data processing. It is not known whether this procedure has an established data standard through any Federal or State agency, however.

Limitations and Assumptions: This procedure stresses the importance of evolutionary origin and regional adaptation. The upper portions of the classification may have value to the manager concerned with importing exotic species, recovering native species, and identifying potential zones for adaptation. The lower portions of the classification are very similar to many others' procedures and should provide suitable data at a more site or habitat specific level. The classification does not provide physical process information nor was it intended to; however, this does not preclude more elaboration on the user's part.

3. Name: The Canadian Wetland Classification System. Provisional — this system is currently being revised and should be released in 1990 (Clayton Rubec, pers. com.).

Authors: National Wetlands Working Group, Canada Committee on Ecological Land Classification.

Reference: National Wetlands Working Group. 1987. The Canadian wetland classification system (provisional edition). Lands Conservation Branch, Canadian Wildlife Service, Environment Canada, Ecological Land Classification Series No. 21. 18 pp.

Objectives: Develop nationally applicable wetland classification system.

Designed Users: Biologists, managers.

Area of Applicability: Canada.
Classification Units, Description, and Data:

Classification Units	Description
Class	Five wetland classes are bog, fen, marsh, swamp, and shallow water.
Form	There are 70 wetland forms differentiated based on morphology, pattern, water type, and underlying soil.
Type	Wetland types are classified according to vegetation physiognomy. These include coniferous and hardwood trees; tall, low, and mixed shrub; forb; graminoid (grass, reed, tall rush, low rush, sedge); moss; lichen; floating and submerged aquatic; and nonvegetated.

Use, Testing, Validation: Procedure is provisional and in the testing processes.

Ease of Application: Procedure is very straightforward. Keys are provided within each class to help a user find the correct form.

Use in Defining System Response and Potential: Form keys contain some physical information that could be used in developing some system responses; however, the intention of the procedure was to strictly classify without addressing response.

Use in Determining State of System: Based on the form key, the descriptions given are very close to what might be considered a system state. However, the concept of succession and progression is not inherent to the procedure.

Relation to Other Procedures: The procedure utilizes standard soil taxonomy. No references to any United States standards could be found.

Automated Data Processing: The data that is collected during the wetland inventory and/or classification is entered into the Canadian Wetland Registry (Kroetsch et al. 1988). This registry system is a computerized data base holding wetland information on location, climate, chemistry, hydrology, soils, and vegetation community or composition.

Limitations and Assumptions: While some of process concepts are handled in the form key, the classification does not attempt to educate the user in why the forms occur. The classification system is meant to be a complimentary text to National Wetlands Working Group, Canada Committee on Ecological Land Classification (1986), entitled "Wetlands of Canada," a definitive knowledge base on Canada's wetlands which serves as both an educational and management reference.

4. Name: Riparian Zone Associations of the Deschutes, Ochoco, Fremont, and Winema National Forests.

Authors: Bernard L. Kovalchik.

Reference: Kovalchik, B.L. 1987. Riparian zone associations: Deschutes, Ochoco, Fremont, and Winema National Forests. USDA Forest Service Region 6 Ecology Technical Paper 279-87 Pacific Northwest Region, Portland, Oregon. 171 pp.

Objectives: This product describes the general geographic, topographic, edaphic, functional, and floristic features of riparian ecosystems. It describes successional trends and predicts vegetative potential on disturbed riparian ecosystems and presents information on resource values and management opportunities. It contributes to the broad regional classification program of the USDA Forest Service, Region 6.

Designed Users: Biologists, foresters, range conservationists, engineers, hydrologists, managers.

Area of Applicability: Central and southern Oregon. Concepts of this system can be applied anywhere.

Classification Units, Description, and Data:

Classification Units	Description
Upland Ecosystem, Transitional Ecosystem, Riparian	While not actually classified, a distinction is made between upland, transitional, and riparian ecosystems. Riparian ecosystems are those next to water where vegetation is on the perpetual water source. Transitional ecosystems occur between the riparian and upland. Transitional ecosystems do not have mesophytic vegetation such as alders, sedges, and willows, yet are markedly different from the uplands. Transitional areas include inactive flood plains, terraces, toe-slopes, and meadows having high water during a portion of the year.
Physiographic Area	This is the broadest level of the classification and integrates similar climatic, geologic, and geomorphic processes.
Riparian Landform	This intermediate level reflects similarities in elevation, valley gradient, fluvial processes, water regime, and soils.
Riparian Association, Community Type, Fluvial Surface	This is the lower level and is determined by site environments reflected in the types of vegetation potentially dominated by the site. Riparian associations (or community types) differ from each other with respect to land management opportunities, can be identified at any level of disturbance, have a limited variation in species composition, and have a limited variability in productivity. The riparian

	association is assumed to be the stable plant community on a particular site provided no major changes in the fluvial surface or water regime occur. Essentially, a community type may be a subset of a riparian association and may develop into a riparian association through normal successional stages of development. A community type (as described, and not one specific site) may also be seral to several riparian associations.
Other Attributes	Additional modifiers include soils, climate, and management information. Management information includes livestock, wildlife and fisheries potential, fire effects, silvicultural production and considerations, potential and pathways for recovery, and related studies.

Use, Testing, Validation: The publication is, in itself, a test and validation. The document is very useful. It includes several keys to define associations and communities from vegetation and landforms. The classification has been in use for 3 years and is well received by U.S. Forest Service managers (Kovalchik, pers. com.).

Ease of Application: The procedure is straightforward. Its ease of application is probably dependent on the experience of the field personnel doing the vegetation mapping and identification. The geomorphic-based alternative for predicting vegetation potential has proved effective for managers without taxonomic skills.

Use in Defining System Response and Potential: The procedure requires some thought to produce system response estimates. Geomorphology, at the landform level (64 landform cross-sections given) along with the geomorphic key to vegetation potential can be very useful in defining system response and is one of the best features of the publication.

Use in Determining State of System: The procedure determines associations (i.e., site succession). Reference are made to other potentials from the association descriptions based on changes in water regime, which is approaching the concept of states and site progression.

Relation to Other Procedures: This procedure relates to standard Daubenmire classification, and uses physiographic regions modified from Baldwin (1964) and Franklin and Dyrness (1973). Nothing limits this procedure from being used with the USFWS Cowardin et al. (1979) procedure; everything needed is supplied. It is also conceptually related to ecological site classification at the association/community levels.

Automated Data Processing: The procedure does not appear to be readily converted to a standard data base management system except at the landform level, which will easily fit into a geographic information system. The knowledge supplied in the descriptions would work well in an expert system type of environment.

Limitations and Assumptions: As presented, the author has done a superb job of getting to the manager's need.

5. Name: Classification and Management of Riparian and Wetland Sites in Montana.

Authors: Paul Hansen, Robert Pfister, John Joy, Dan Svoboda, Keith Boggs, Lew Myers, Steve Chadde, and John Pierce.

References: Batchelor, R., M. Erwin, R. Martinka, D. McIntosh, R. Pfister, E. Schneegas, J. Tayor, and K. Walther. 1982. A taxonomic classification system for Montana riparian vegetation types. Montana rural Area Development Committee, Bozeman, Montana. 13 pp.

Boggs K., P. Hansen, R. Pfister, and J. Joy. 1990. Classification and management of riparian and wetland sites in northwestern Montana, draft version 1, Montana Riparian Association, School of Forestry, University of Montana. 217 pp.

Hansen, P., S.W. Chadde, and R. Pfister, 1988. Riparian dominance types of Montana. Montana Forest and Conservation Experiment Station, School of Forestry, University of Montana, Missoula, Montana. Misc. Pub. No. 49. 411 pp.

Hansen, P., K. Boggs, R. Pfister, and J. Joy. 1990. Classification and management of riparian and wetland sites in southwestern Montana, draft version 2a, Montana Riparian Association, School of Forestry, University of Montana. 292 pp.

Hansen, P., K. Boggs, R. Pfister, and J. Joy. 1990. Classification and management of riparian and wetland sites in central and eastern Montana, draft version 2, Montana Riparian Association, School of Forestry, University of Montana. 279 pp.

Objectives: Develop a riparian ecological site classification for Montana to assist in the identification, description, communication, and management of riparian areas by resource managers. Describe the general geographic, topographic, edaphic, functional, and floristic features of riparian ecosystems. Describe successional trends and predict vegetative potential on disturbed riparian sites. Present information on resource values and management opportunities. In addition, the classification can be used for mapping and inventory of the riparian zone.

Designed Users: Managers, biologists, hydrologists, engineers, resource specialists.

Area of Applicability: The approach is both a conceptual framework and an operational taxonomy that is applicable everywhere. The actual "types" described in the work are applicable to southwestern, central, northwestern, and eastern Montana.

Classification Units, Description, and Data:

Supplement to classification units: The ecological concepts and terminology used essentially follow the work of Daubenmire (1959), Daubenmire (1968), Daubenmire and Daubenmire (1968), Daubenmire (1970), Daubenmire (1978), and Kovalchik (1987). The hierarchical system is described by Daubenmire (1978). The following is a brief discussion of the hierarchical system.

Classification Units	Description
Region	Regions have a high degree of physiognomic uniformity among the climatic climaxes, and a gross similarity of climates throughout. However, taxonomic similarity is not a requirement.
Province	Provinces are zones in which the dominants of the climatic climaxes have had much the same geologic history, exhibit a strong thread of taxonomic continuity, and occur in climates of somewhat similar pattern. A finer subdivision of a province is a section.
Zones	Zones are the entire area over which zonal soils support what may be considered the same type of climatic climax. Zones are areas of essentially homogeneous macroclimate as indicated by a common climatic climax. The zones fit together on a map as a mosaic without overlap, although the plant association that is climatic climax in one zone usually occurs as an edaphic or topographic climax in a contiguous zone, where it becomes restricted to an environment which compensates for the relatively unfavorable macroclimate.
Series	A series is a group of habitat types having the same potential climax overstory.
Habitat Types	A habitat type is all the area of land capable of supporting the same climax plant association whether this be climatic, edaphic, or topographic climax. (A plant association is a kind of plant community represented by stands occurring in places where environments are so closely similar that there is a high degree of floristic uniformity in all layers.)
Phase	A phase is a subdivision of a habitat type representing a characteristic variation in climax vegetation and environmental conditions.
	Additional Ecological Terms
Riparian Association	A riparian association is a plant community type representing the latest successional stage attainable on a specific hydrologically influenced surface (equal to potential natural community). Because the riparian association is the end result of plant succession, it reflects the most meaningful integration of environmental factors affecting vegetation. [Because of the difficulties of defining climax in the classical sense for flood plain environments, this system currently follows the lead of Kovalchik (1987) in using the term riparian association to represent the latest successional stage available.]

Riparian Site Type	The riparian site type is the area of land occupied or potentially occupied by a specific riparian association (e.g., a vegetation based ecological site type for riparian areas). Each riparian site type represents a relatively narrow segment of environmental variation having a certain potential for vegetation development. Although any given riparian site type may support a wide variety of disturbance induced or seral vegetation, the ultimate product of vegetational succession anywhere within that riparian site type will be a similar plant community. Therefore, the riparian site type is an ecological site classification that uses the plant community as an indicator of integrated environmental factors as they affect species reproduction and plant community development.
Community Type	A community type is an aggregation of all plant communities distinguished by floristic and structural similarities in both overstory and undergrowth layers. Community types are considered to represent seral stages.

Site Descriptions

Location and Riparian Landforms	Presents typical elevation range and landforms associated with each type.
Floristic Characteristics of Sampled Stands	Describes the vegetation on the site.
Potential Natural Community	Used for seral stages (community types) and describes the proposed successional pathway(s) to the climax vegetation.
Soils	Follows standard SCS taxonomy and description of moisture regime.
Adjacent Communities	Describes adjacent wetter or drier sites. This information gives the user a mental picture of the "types" position on the landscape.
Management Information	The following management information is presented: livestock, timber, wildlife, fisheries, fire, soil management and rehabilitation opportunities, recreational uses and considerations. In addition, the following information (by species) is presented: 1) forage palatability (cattle, sheep, and horses), 2) energy value, 3) protein value, 4) thermal or feeding cover values (elk, mule deer, whitetail deer, upland game birds, waterfowl, small nongame birds, and small mammals), 5) food value or degree of use (elk, mule deer, whitetail deer, antelope, upland game birds, waterfowl, small

	nongame birds, and small mammals), 6) potential biomass production, 7) erosion control potential, 8) short-term revegetation potential, and 9) long-term revegetation potential.
Other Studies	Summary of similar sites.

Use, Testing, Validation: The approach is both a conceptual framework and an operational taxonomy that is applicable everywhere. The methodology is being used throughout Montana. The document provides managers with site potentials and management information.

Ease of Application: The procedure is straightforward. Its ease of application is dependent on the experience of the field personnel doing the vegetation mapping, identification, and interpretation.

Use in Defining System Response and Potential: The procedure's strength is in its attempt to understand system response and site potential for the purpose of providing management information.

Use in Determining State of System: A goal of the procedure is to identify associations (i.e., site succession). An effort was made to reference other potentials from the association descriptions based on changes in water regime.

Relation to Other Procedures: The procedure uses standard ecological classification principles. The ecological concepts and terminology used essentially follow the work of Daubenmire (1968), Daubenmire and Daubenmire (1968), Daubenmire (1970), Daubenmire (1978), and Kovalchik (1987). It is conceptually similar in part to ecological sites.

Automated Data Processing: The procedure uses the USFS Region 1 Ecodata sampling and automated data processing system. The results of the procedure would not be easily converted to a standard ADP system. However, it would work well in a knowledged based system (expert system).

Limitations and Assumptions: As presented, the authors have done a superb job of getting to the manager's need.

6. **Name:** Classifying Rangeland Riparian Areas: The Nevada Task Force Approach.

Authors: Sherman Swanson, Ray Miles, Steve Leonard, and Kenneth Genz.

Reference: Swanson S., R. Miles, S. Leonard, and K. Genz. 1988. Classifying rangeland riparian areas: the Nevada task force approach. Journal of Soil and Water Conservation, 1988. 43:3.

Objectives: Develop a system that is interdisciplinary, hierarchical, simple yet reliable, useful for management, related to ecological potential, and mappable.

Designed Users: Biologists, soil scientists, hydrologists, managers.

Area of Applicability: Rangelands, but concepts are applicable everywhere.

Classification Units, Description, and Data:

Classification Units	Description
Physiographic Region	Major land classes as defined by Brown and Kerr (1979).
Major Riparian Areas	Delineates between stream and nonstream types.
Stream Type	Stream types are classified using a geomorphic based system developed by Rosgen (1985).
Nonstream Type	Nonstream types include lake, reservoir, pond, pool, spring, seep, and irrigation conveyance.
Ecosystem - Riparian, Aquatic	Ecosystem is separated into either aquatic or riparian based effectiveness of the open water column. Aquatic ecosystems include nonpersistent emergent, aquatic beds, and areas not vegetated (bars). Cowardin et al. (1979) can be used to describe aquatic ecosystems at this point.
Subsystem	Only the riparian ecosystem is described in the subsystem. This includes moisture regime classes as suggested by Johnson et al. (1984): hydroriparian, mesoriparian, and xeroriparian.
Structure Class, Subclass	Structural class is similar to the Cowardin et al. (1979) class, but is related to perceived potential natural community. Structural classes include: forest, woodland, shrub, herb, nonvegetated. As with class, subclass attributes are based on potential natural community and include: evergreen, deciduous, mixed, tall, low, nonvegetated.

Ecological Site	A distinctive type of land that differs from other kinds of land in its ability to produce a characteristic potential natural community.
Community Type	The existing/dominant plant community distinguished by floristic and structural similarities.
Stream Subtype	Used under the associated stream type to describe in detail the stream reach being classified. The modifiers used by Rosgen (1985) are suggested to describe flow regimen, size, organic debris/channel blockages, depositional features, and meander patterns.
Naming Conventions	The physical site attributes are given in the beginning of the site name and are separated by a forward slash (/). The ecological site attributes are given on the right-hand side of the physical attributes and separated from them with a semicolon (;). Codominants are separated using a hyphen (-).

Use, Testing, Validation: Currently under testing through the University of Nevada, Reno.

Ease of Application: The system appears about as easy as any other procedure to apply. However, since it is more comprehensive than most procedures, there are more data requirements and may require more expertise.

Use in Defining System Response and Potential: The procedure has incorporated the concept of potential natural community, and as such, has recognized one form of system response. It has also incorporated a great deal of geomorphic information, making the tie between major physical systems more possible.

Use in Determining State of System: Procedure has all necessary components to determine site progression.

Relation to Other Procedures: To a large degree, the procedure maintains consistency with Soil Conservation Service standards for soil descriptions and to a lesser degree with the USFWS Cowardin et al. (1979) wetlands procedures. The procedure does deviate in naming conventions at the system, subsystem, and class level, but there are no major deviations in concept.

Automated Data Processing: The procedure is too new to evaluate, but does appear to be suitable to a data base management system.

Limitations and Assumptions: As written, the procedure is limited to inland areas; however, this could be expanded by following Cowardin et al. (1979) more closely. The naming convention may be too complex to allow for easy description and cross-referencing.

7. Name: Classification of Riverine Riparian Habitats for Management of Fisheries Resources.

Authors: William S. Platts, Sherman E. Jensen, Frank Smith.

Reference: Platts, W., S. Jensen, and F. Smith. 1988. Preliminary classification and inventory of riverine riparian habitats livestock/fishery study areas, Nevada. Progress Report I. Nevada Department of Wildlife, Elko, Nevada. 127 pp.

Objectives: Identify the existing state structure and function and their respective physical and biological processes. Identify the natural state under present set of conditions and the variability of this state over time. Estimate achievable state conditions and identify units of similar potential even though present states are not identical. Determine the state direction the system is moving (trends). Determine the time intervals occurring between state changes under known applications of stresses or benefits. Identify Poor and Best Management Practices. Determine limiting factors that determine the biotic carrying capacity for each state. Transfer knowledge and experience over space. Evaluate the influence of natural and artificial geomorphic-physical conditions within the watershed on the fisheries. Determine attainability (as described in the Water Quality Act) of riverine riparian habitats in a regional perspective. Allow valid establishment of control and treatment sites for assessing non-point source impacts to riverine riparian habitats. Display and describe riverine riparian habitats at selected hierarchical levels. Identify those variables that are sensitive for identifying and assessing non-point source impacts (monitoring). Be hierarchical and mappable. Display the regional characteristics of riverine riparian complexes and describe their inherent capabilities and potentials. The process must be amenable to hypothesis or model testing.

Designed Users: Biologists, hydrologists, engineers, managers, resource specialists.

Area of Applicability: Anywhere.

Classification Units, Description, and Data:

Classification Units	Description
Domain	Subcontinental area of related climates.
Division	A subset of domain delineating single reference regional climate as defined by Trewartha and Horn (1980).
Ecoregion	A subset of division based on land surface form as defined by Fenneman (1931). A broad vegetation region with the same types of zonal soils. Climatic climax at the level of Kuchler's (1964) potential vegetation types. Four major criteria are landform, potential natural vegetation, land use, and soil.
Geologic District	A subset of ecoregions delineating more homogeneous areas banding together uniform landforms at the level of Hammond's land-surface form regions.

Land Type Association	Groups of closely related types within a geologic district with recurring patterns of landforms, soil, and vegetation.
Land Type	Group of neighboring phases within a land type association with similar soil series or families with similar plant communities at the level of Daubenmire's (1968) habitat types (e.g., valley bottom).
Valley Bottom Class	Group of neighboring sites within land types having similar soil properties with closely related habitat types.
Riverine-Riparian Complexes	Repeating units within valley bottom classes that are made up of distinctive groups of riverine and riparian types.
Riverine and Riparian Community Types[1]	Repeating types within riverine and riparian complexes dictated by the location and combination of soils and water.
Riverine Site	What's at that final point (i.e., pool, riffle).
States	Are used to describe functional position within a number of major site environments for a particular piece of ground fixed in space and the cause/effect relationships that determine its position.

Ecological Considerations: Daubenmire concepts of succession, climax, ecological site are incorporated at the complex and community type level.

Use, Testing, Validation: The method has undergone testing and is now being applied in a regional scale to northern Nevada.

Ease of Application: The upper hierarchical data requirements are fairly easy to obtain though the use of existing resource information. The data requirements at the complex and community type level require field data collection similar to that required in most of the Daubenmire procedures. The site information can be as complex as the user wants to make it. The procedure would require personnel from several areas of expertise.

Use in Defining System Response and Potential: System response is a key element and one of the objectives of the procedure.

Use in Determining State of System: The state of the system is inherent in the procedure.

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[1] Riverine and riparian types are two distinct mappable uses, with riverine ecosystems being that within the channel.

Relation to Other Procedures: Vegetation classification followed is consistent with Youngblood et al. (1985). The procedure uses standard landform description, soil taxonomy, moisture regimes, and has flexibility to incorporate many types of attributes.

Automated Data Processing: Not easily converted to a standard ADP system. Would work well in a knowledge based system (expert system), however.

Limitations and Assumptions: The procedure uses such an integration of various hierarchical attributes that major limitations are unlikely. The procedure integrates both the riverine and riparian system as it is viewed in the upper and middle levels of the hierarchical structure.

8. Name: An Ecological Characterization of Rocky Mountain Montane and Subalpine Wetlands.

Authors: John T. Windell, Beatrice E. Willard, David J. Cooper, Susan Q. Foster, Christopher F. Knud-Hansen, Lauranne P. Rink, George N. Kiladis.

Reference: Windell, J., B. Willard, D. Cooper, S. Foster, C. Knud-Hansen, L. Rink, and G. Kiladis. 1986. An ecological characterization of Rocky Mountain montane and subalpine wetlands. National Ecology Center, Division of Wildlife and Contaminant Research, USDI, Fish and Wildlife Service, Washington, DC, Biological Report 86(11). 298 pp.

Objectives: Provide a comprehensive review of Rocky Mountain wetlands. Identify gaps existing in the scientific literature. Provide information for the assessment, planning, and permitting of activities affecting wetlands. Provide an educational source for anyone interested in the ecological functioning and value of high-elevation wetlands. The report also classifies Rocky Mountain wetlands within a system hierarchy that recognizes international wetland terminology, considers duration, depth, velocity of water and frequency of flooding, and variety and concentration of mineral nutrients as the two dominant factors determining pattern of species and communities.

Designed Users: Biologists, ecologists, planners, managers.

Area of Applicability: Rocky Mountains.

Classification Units, Description, and Data:

Classification Units	Description
Water Regime	Highest level of the classification and includes: permanent shallow, standing water; communities with seasonal or permanent high water tables, but without permanent standing waters; communities adjacent to running waters; communities in running water.
Subcategory	Permanent shallow, standing includes: floating, rooted submerged, rooted floating leaved, rooted emergent. Seasonal water regime: herb wetlands, shrub wetlands, forested wetlands, unvegetated. Running water regime: moss, herbaceous, shrub, forested, unvegetated.
Substrate	Mineral or organic.
Water Type	Fresh, saline, minerotrophic, ombrotrophic.
Ecosystem Type	Types listed to conform to international nomenclature: fen, bog, marsh-meadow, saline marsh-meadow, carr, shrub bog, shrub wetland, saline shrub wetland, deciduous angiosperm forest, moss wetlands, herbaceous wetland, shrub wetland, coniferous forest.

Fen	Sedge, grass, or reed-dominated minerotrophic peatlands. The water table is at, or close to, the surface most of the time. Minerotrophic means that the water source has been in contact with mineral soils and provides a much greater supply of nutrients.
Bog	A generalized term for a wetland that develops in a depres sion, such as a lake with poor drainage. Generally character ized by extensive peat deposits, acidic water, floating sedge, heath shrubs, and often the presence of coniferous trees. The water table is usually close to the surface without standing water (except where there are open ponds).
Marsh	A wetland on mineral soils dominated by herbaceous (nonwoody) plants, often developing in shallow ponds or depressions, river margins, tidal areas, and estuaries. Waters are not acid.
Meadow	Refers to herbaceous wetlands on mineral soil and may be synonymous with wet meadow. Generally occur in season ally flooded basins and flats, and soils usually are not wet during the entire growing season.
Carr	Wetlands that occur on organic soil composed of minerotrophic peat, having greater than 25 percent shrubs that may form very dense cover creating thicket, or the overstory may be open. Usually there is abundant water that retards peat decomposition. Willow is common dominant in Rocky Mountain carrs.
Shrub Wetland	Wetlands dominated with shrubs found on either organic or mineral substrate. When on organic substrate with an ombotrophic water source (water source from precipitation which is also the major source of nutrients), they are called a shrub bog. When on organic substrate with a minerotrophic water source, they are considered a carr. When on mineral substrate with a fresh water source, they are called a shrub wetland, with a saline water source, a saline shrub wetland.

Levels below the subcategories are not formally defined, but are assumed to be similar to that of the USFWS (Cowardin et al. 1979) procedure.

Use, Testing, Validation: This procedure was intended to present a broad description of the wetland systems in the Rocky Mountains along with an abundance of supportive information on geology, climate, hydrology, and management. The document provides information into wetland ecology that is considered necessary reading to anyone attempting to describe or manage wetlands.

Ease of Application: The classification system appears fairly easy to apply; however, the entire report format is quite lengthy. The document as a whole is a tremendous characterization effort and would serve as a model for other ecoregions. A document similar to this would provide very helpful assistance to a more detailed classification.

Use in Defining System Response and Potential: The text of the document has a good discussion on system response at some levels but is inconsistent from type to type. The information provided would be useful in defining system response.

Use in Determining State of System: The chapter dealing with ecological process discusses theory and gives practical examples of system state change. The applications are broad, however.

Relation to Other Procedures: The document presents a table that cross-references other classification procedures. The procedure uses internationally recognized terms for wetland. As stated above, this document should be considered necessary reading to anyone attempting to describe or manage wetlands.

Automated Data Processing: The procedure as presented is not well-suited for ADP other than in a knowledge-based system.

Limitations and Assumptions: Classification nomenclature on an international level could be easily incorporated into many other procedures. Many of the concepts are presented throughout the document. The lack of an index makes rapid retrieval of such information difficult. The document does contain a great deal of information that should be reviewed by wetland classifiers and managers in understanding a broad overview of the landscape.

9. Name: Ecosystem Classification Handbook.

Authors: Wendel J. Hann and Mark E. Jensen.

Reference: Hann, W.J., and M.E. Jensen. 1987. Ecosystem classification handbook, Chapter 4 - Ecodata sampling methods. Region I, USDA, Forest Service. Missoula, Montana.

Objectives: The classification handbook is a total effort to integrate data inventory and analysis of terrestrial and riparian habitats and to combine this information into classification. The procedure is a means for the collection, management, and interpretation of data. Just about any taxonomical classification would be served by the ECODATA system.

Designed Users: Land managers and biologists.

Area of Applicability: United States (although system could be used anywhere).

Classification Units, Description, and Data:

The procedure reviewed did not include any typically hierarchical format, although the attributes collected during the inventory, the inventory design and mapping procedures, and the nomenclature all point to a very complete but flexible hierarchical structure. The units below are given in order of typically structured hierarchical procedures. Mapping terms are:

Classification Units	Description
Polygon	A contiguous unit of land which is delineated on a map or aerial photo within a closed boundary. Can contain similar or dissimilar strata.
Stand	A type of polygon which is designed to describe one dominant stratum type within a uniform environmental setting.
Stratum	A vegetation classification category defined at any level of resolution dependent upon classification needs. A vegetation type stratum contains all the land within a defined vegetation type. A community type stratum contains all the land within one particular seral or climax community type.
Complex	Where two or more dissimilar vegetation stratum are in the same stand (polygon) and each makes up greater than 20 percent of the stand area.
Inclusion	Where a dissimilar vegetation stratum comprises less than 10 percent of the stand or polygon area (vegetation).
Range Type	Delineation of major form type riparian and nonriparian (grassland, meadow, perennial forb, sagebrush, browse-mountain shrub, conifer, rock, broadleaf trees, badlands).

Ecosystem	All the land that has potential to produce similar structural life forms and has similar broad environmental characteristics (nonvegetated, conifer, juniper, shrub dominated wetland, grassland/grass-steppe/mountain grass).
Habitat Type	All the land capable of producing similar plant communities at climax. A habitat type name incorporates those plant species which best define the environment (typically two species). Habitat types sometimes are estimated since existing vegetation types may be seral because of disturbance.
Vegetation Type	All the plant communities that are similar with respect to both species type and abundance within all layers. Characterized by minimal variability in plant species composition.
Community Type	All the plant communities in which the dominant and/or indicator species of corresponding layers are similar.
Habitat Phase	A refinement of a habitat type in which additional indicator plant species are used to define a more narrow range of environmental conditions.

Physical Terms

Site Type	All sites possessing similar soil, parent material, slope position, shape, aspect, elevation, and climate.
Parent Material	Specific rock type.
Hydrologic Unit Code	USGS code for basin, sub-basin.
Stream Order	Standard Horton stream order.
Valley Bottom Type	Valley gradient.
Valley Bottom Subtype	Valley form and sideslope.
Stream Classification	Class as defined by Rosgen (1985) A1, B2, etc., including debris, stream size, flow regimen, depositional feature, meander pattern, sinuosity, form, bankfull gradient.

Other miscellaneous measurements include streambank canopy, overhang, streambank cover, bank slope, and undercut.

Use, Testing, Validation: Riparian portion of method is in draft.

Ease of Application: The system is easy to apply and particularly useful with aerial photographs. The system becomes more time consuming as additional field attributes are added. Its ease of application would be dependent on the approach used to interpret the data.

Use in Defining System Response and Potential: The procedure as described does not address system response other than vegetation ecology, although there are many attributes, such as stream type, that could be used in the interpretation of system response. Site potential is inherent in the data storage and analysis system. The attributes collected will allow a more complete estimate of system response.

Use in Determining State of System: The USFS procedure can be used to describe the state of a riparian system, but the inventory would have to be designed to deal with cause and effect relationships that would be useful in determining potential state changes in a riparian system.

Relation to Other Procedures: The USFS procedure does a good job of keeping open to detailed attributes, such as soils information, landforms, and attributes. Standard soil taxonomic classification can be placed into the procedure at the modifier level. The procedure appears to fit into other vegetation classification schemes, such as those done on a regional or provincial level. The ECODATA system appears to be a good data manager that would benefit the analysis of any type of wetland/riparian classification effort.

Automated Data Processing: ADP is inherent in the procedure and includes automated analysis for determining a number of characteristics including community type.

Limitations and Assumptions: The full application of all data attributes in the procedure recognizes nearly all important vegetation, hydrologic, and geomorphic characteristics. Thus it requires a diversified and experienced team to conduct the full application of the data collection described in the document. The procedure appears flexible as it does not tie the user down to any particular taxonomic system, but retains data integrity (with the exception of stream morphology). This allows the user to move into many types of classification systems easily and to provide important additional descriptions.

10. Name: Classification of Wetlands and Deepwater Habitats of the United States.

Authors: Lewis M. Cowardin, Virginia Carter, Francis Golet, and Edward LaRoe.

Reference: Cowardin L.M., V. Carter, F. Golet, and E. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States, 1979. U.S. Department of the Interior, Fish and Wildlife Service, FWS/OBS-79/31, Washington, DC. 103 pp.

Objectives: The classification is designed for use in a new inventory of wetlands and deepwater habitats and is intended to describe ecological taxa, arrange them in a system useful to resource managers, furnish units for mapping, and provide uniformity of concepts and terms. The system provides hierarchical levels from the broadest (marine, estuarine, riverine, lacustrine, palustrine) to the lowest level, dominance type, which is named for the dominant plant or animal form of the area.

Designed Users: Land managers and biologists.

Area of Applicability: United States (although system could be used anywhere).

Classification Units, Description, and Data:

Classification Units	Description
System	Basic water source/feature (marine, estuarine, riverine, etc.).
Subsystem	Basic water persistence attributes (subtidal, intertidal, lower perennial, upper perennial, etc.).
Class	Gross substrate/vegetation form (rock bottom, aquatic bed, emergent wetland, rocky shore, forested, etc.).
Subclass	Specific substrate/vegetation type (bedrock, sand, mud, needle-leaved evergreen, broad-leaved deciduous, etc.).
Dominance	Dominant plant/animal species (horsetail, black cottonwood, willow, caddisfly, crayfish).
Modifiers	Site specific attributes of soil, regime, water chemistry, and land alteration (salinity, pH, flooding condition, mineral or organic, farmed, diked, etc.).

Use, Testing, Validation: This system is currently in use by many agencies for the general inventory and classification of habitats. It has been used in small and large applications. Products from the classification can give the manager a good overview of the resource.

Ease of Application: The system is easy to apply and particularly useful with aerial photographs. The system becomes more complex as modifiers are added to the description, as with specific hydrology and water chemistry.

Use in Defining System Response and Potential: The USFWS procedure does not consider responsiveness or functional processes.

Use in Determining State of System: The USFWS procedure can be used to describe the state of a riparian system, but is not designed to deal with cause and effect relationships that would be useful in determining potential state changes in a riparian system.

Relation to Other Procedures: The USFWS procedure does a good job of keeping open to more detailed modifiers, such as soils information. Standard soil taxonomic classification can be placed into the procedure at the modifier level. The dominance level is fairly standard as vegetation description goes. Some differences between other procedures can be expected in the delineation between overstory, dominance density, etc. The procedure appears to fit into other vegetation classification schemes, such as those done on a regional or provincial level. Overall, the procedure recognizes the difference between fluvial surfaces and major vegetation forms at a level that makes it reasonably easy to merge with classification procedures for other considerations, such as geology, climate, landforms, etc.

Automated Data Processing: ADP was not discussed in the procedure. Since all but the lower hierarchy are defined (5 system names, 8 subsystem names, 11 class names, and 28 subclass names), most of a classification could be standardized and used in ADP very easily. When more detail is demanded from the dominance and modifier description, ADP applications will be more complex.

Limitations and Assumptions: The procedure is not designed to reflect potential natural communities or community ecology. However, a detailed classification using some of the other procedures discussed above could provide information fitting the protocol of this procedure.

11. Name: Riparian Community Type Classification of Eastern Idaho-Western Wyoming.

Authors: Andrew P. Youngblood, Wayne G. Padgett, and Alma H. Winward.

Reference: Youngblood, A.P., W.G. Padgett, and A.H. Winward. 1985. Riparian community type classification of eastern Idaho-western Wyoming. USDA Forest Service, Intermountain Region, R4-Ecol-85-01. 78 pp.

Objectives: To contribute to the broad regional classification program of the USDA Forest Service by developing a riparian community type classification for eastern Idaho and western Wyoming. To describe the general geographic, topographic, edaphic, and floristic features of each community type. To describe the successional trends for each community type, where possible. To present information on resource values and management opportunities for each community type.

Designed Users: Land managers and biologists.

Area of Applicability: Eastern Idaho, western Wyoming (although system could be used anywhere).

Classification Units, Description, and Data:

Classification Units	Description
Canopy Cover	The area covered by the generalized outline of an individual plant's foliage, or collectively covered by all individuals of a species within a stand or sample area. Canopy cover percentages are a determining factor in distinguishing community types, the basic unit of this taxonomical system as described in Daubenmire (1968).
Soils	Soils were classified to the family level using standard pedon description methods (USDA-SCS 1975). Available water capacity (inches of water/inches of soil) was estimated for the top 50 cm (20 inches) using guidelines developed by the U.S. Department of Agriculture, Soil Conservation Service (1983). A general characterization of geologic materials was determined from geologic maps.
Community Type	An aggregation of all plant communities distinguished by floristic and structural similarities in both overstory and undergrowth layers.

Use, Testing, Validation: Document serves as a test and validation. The procedure, or a similar representation, is used by a number of U.S. Forest Service offices.

Ease of Application: The field data requires a number of statistical procedures to analyze canopy data. However, the application is straightforward and should not be difficult for experienced biologists. Developing relationships among adjacent riparian community types and upland vegetation requires experience.

Use in Defining System Response and Potential: The document recognizes the utility of classification to wildlife, livestock, and fire effects and the aid such a classification provides to many areas of management. The procedure or document does not identify potential natural communities; however, reference is made to a stable community. Stable refers to the condition of little or no perceived change in plant communities that are in relative equilibrium with existing environmental conditions. Stability describes persistent, but not necessarily culminating, stages (climax) of plant community succession.

Use in Determining State of System: The description provided by the procedure included a discussion of succession and management. A general discussion of possible successional pathways are given. The physical information on soils and geology would be helpful in determining the state of the system, but more information on geomorphology would be needed for a complete discussion.

Relation to Other Procedures: This procedure relates well to other taxonomical procedures reviewed and uses standard soil taxonomy and Daubenmire community ecological principles. This document provides one of the first efforts in describing riparian community ecology and the interrelationship with soil and water. Many of the community types described in this document have been recognized elsewhere. This document should be reviewed by anyone new to riparian classification.

Automated Data Processing: ADP is inherent in carrying out the procedure.

Limitations and Assumptions: The procedure recognizes that there are stable communities and provides estimates of successional pathways. This approach would need to be continued to derive the largest benefit to management.

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Appendix A
Riparian Classification Comparison*

Name of Classification or Description	Physiographic Features	Geologic Features	Climatic Features
1. Standard Ecological Site Description	General orientation, geomorphic landform, slope ranges, elevation ranges.	Specific formations, parent rock or material included.	Range of average and seasonal distribution of precipitation and temperature for soil and ambient air.
2. Southwest Wetlands	Inherent to some degree in biogeographic realm.	Not provided.	Inherent in climate zone.
4. Riparian Zone Associations	Provided in description.	Provided in description.	Provided in description.
5. Riparian-Wetland Sites in Montana	Geomorphic landform & orientation, elevation ranges, provided for in narrative.	Provided.	Provided.
6. Nevada Task Force Approach	Provided at ecological site description level as in (1) above.		
7. Riverine Riparian Habitats	Provided as geologic district, land type association, and land type.	Provided as geologic district, land type association.	Provided as domain and division (Trewartha and Horn 1980).
9. Ecosystem Classification Handbook	Includes geomorphic landform, valley bottom type and subtype, Horton stream order.	Parent material description.	Not provided.
10. Wetland and Deepwater Habitats	General, from Bailey 1976.	Not provided.	General, from Bailey1976.
11. Riparian Community Types	Provided.	Provided.	Provided.

* Classifications 3 and 8 are not included.

Riparian Classification Comparison (Continued)

Name of Classification or Description	Soils Features	Water Features	General Physical Features
1. Standard Ecological Site Description	Description of major properties, association of soils, SCS conventions, and soil taxonomy standards.	Stream type as defined by Rosgen. Flow regime, surface-ground-water features.	Given in site description. Similar to a site type.
2. Southwest Wetlands	Not provided.	Not provided.	Not provided.
4. Riparian Zone Associations	Provided.	Riverine systems are not specifically discussed, but water regime and fluvial process are generally covered.	Basic unit is riparian landform. Includes soils, fluvial process and water regime.
5. Riparian - Wetland Sites in Montana	Provide as standard SCS soil taxonomy.	Flow regime and subsurface features are generally covered.	Given in site description. Includes soils, fluvial processes and water regimes.
6. Nevada Task Force Approach	Provided in naming convention.	Stream type as defined by Rosgen. Moisture condition as defined by Johnson and Carothers, 1981.	Provided in naming convention.
—Also provided at the ecological site level of classification—			
7. Riverine Riparian Habitats	Provided in land type, valley bottom units.	Described in riverine - riparian complexes and in riverine types.	Described at the riverine site level.
9. Ecosystem Classification Handbook	Uses SCS conventions.	Stream type as defined by Rosgen.	Basic physical description is called site type.
10. Wetlands and Deep-water Habitats	Provided as modifiers. Uses SCS hydric soils descriptions.	Identified at the subsystem level, substrate at the class and subclass level, water persistence at the subsystem level.	Provided as modifiers.
11. Riparian Community Types	Provided, SCS standard.	Not provided.	Provided.

Riparian Classification Comparison (Continued)

Name of Classification or Description	Ecosystem Description	Existing Vegetation			
		Class	Subclass	Dominance	Composition
1. Standard Ecological Site Description	Major land resource area (MLRA) given.	Can be derived from dominance and composition.		Provided.	Provided.
2. Southwest Wetlands	Inherent in biogeographic realm, formation type, vegetation, regional formation (biome).	Obtained from formation type and regional formation.		Series and association.	Provided.
4. Riparian Zone Associations	Provided.	Can be obtained from dominance information.		Provided.	Provided.
5. Riparian-Wetland Sites in Montana	Provided. Can be used with USFWS (10).	Provided. (called formation class and subclass).	Provided.	Provided.	Provided
6. Nevada Task Force Approach	Generally provided by land classes.	Provided.	Provided.	Provided.	Can be provided.
	—Also provided at the ecological site level of classification—				
7. Riverine Riparian Habitats	Provided.	Can be obtained from dominance information.		Provided.	Provided.
9. Ecosystem Classification Handbook	Provided.	Provided in range, ecosystem, and vegetation type.		Provided.	Provided.
10. Wetland and Deep-water Habitat	Generally provided at system level as marine, estuarine, riverine, etc.	Provided.	Provided.	Provided.	Not required.
11. Riparian Community Types	Provided.			Provided.	Provided.

Riparian Classification Comparison (Continued)

Name of Classification or Description	Functional Ecological Description	PNC	Ecological Units Ecological Site	Community Type
1. Standard Ecological Site Description	Provided in site narrative.	Provided.	Provided.	Provided in site interpretation narrative.
2. Southwest Wetlands	Inherent to some degree at all levels.	Not specifically provided.		Association.
4. Riparian Zone Associations	Provided.	Provided.	Riparian association.	Provided.
5. Riparian - Wetland Sites i n Montana	Provided in site interpretation.	Provided; called habitat type, or riparian assiciation in describing what could occur on a riparian site type.		Provided in site description.
6. Nevada Task Force Approach	We assume a site description would accompany the site name.	Provided.	Provided.	Provided, called riparian community.
7. Riverine Riparian Habitats	Provided. - Also includes riverine-riparian complexes which appear very useful in relating riparian and riverine sites -	Provided.	Provided.	Provided.
9. Ecosystem Classification Handbook	Provided.	Provided; called habitat type, and a more detailed habitat type phase.		Provided; includes broader unit, called vegetation type, which groups similar community types.
10. Wetland and Deepwater Habitats	Not included.	——————Not required—————— Could be placed as modifiers.		
11. Riparian Community Types	Provided.	Not given. Stable community given.	Not provided.	Provided.

Riparian Classification Comparison (Continued)

Name of Classification or Description	Description of Procedures Relevance to Site Management
1. Standard Ecological Site Description	Provided in site interpretation narrative. Relates various seral stages or community types with management actions such as grazing, wild fire, recreation. Also provides water-soil interaction description and related limiting factors.
2. Southwest Wetlands	Not provided, but could be easily accommodated in a site description, provided cause and effect and site correlation information is collected.
4. Riparian Zone Associations	Provided in site interpretation narrative. Relates various plant zone associations and community types with management actions such as grazing, wildfire, and recreation. Also provides water-soil interaction, Kovalchik description, and related limiting factors.
5. Riparian-Wetland Sites in Montana	Provided in site interpretation narrative. Relates various community types with management actions such as livestock, timber, wildlife, in fisheries, fire, soil management and rehabilitation opportunities, and recreational uses and considerations.
6. Nevada Task Force Approach	The reference provides an example of how site management relates to the classification system. It is assumed that site management features would be included in a classification conducted by the procedure.
7. Riverine Riparian Habitats	Provided in site interpretation narrative. Relates various community types with management actions such as grazing, wildfire, recreation, etc. Also provides water-soil interaction description and related limiting factors.
9. Ecosystem Classification Handbook	The ECODATA procedure includes a number of analysis techniques specifically for management. It is assumed that site management features would be included in classification documentation produced as a part of the interpretation and analysis of the ECODATA data base.
10. Wetland and Deep-water Habitats	Not provided.
11. Riparian Community Types	Some information is given on application to site management. Management information is given under succession/management sections.

Appendix B
Converting Between Classification Procedures (Vegetation)

Users of riparian classification procedures may want to convert from one procedure to another or may want to structure their inventory data to fit more than one classification process. Generally, it is difficult, if not impossible, to take a classification of lesser detail and fit it into a classification of greater detail. For example, it would be impossible, without additional data, to take information from National Wetlands Inventory, which utilizes the procedure of Classification of Wetlands and Deepwater Habitats, Cowardin et al.(1979), at a very general level, and place it into a process designed for community types and/or associations (potential natural community). On the other hand, an inventory that utilizes a very detailed level of vegetation inventory (dominance of species), within Cowardin's (1979) procedure, could be used in most of the other classification processes with some adjustment.

Where a procedure of classification has developed a key, such as in Montana, parts of Oregon, and eastern Idaho, general information on the composition of vegetation sites from less detailed classifications may require only minor field checking to make use of the information.

Users will have a much easier time classifying sites utilizing an existing classification in an area where it is applicable compared to developing new classifications in areas where none exist.

When transferring management recommendations from existing classifications to new areas, it is important that site information be collected to ensure that not only the vegetation is comparable, but that the site functions are comparable as well.

The following information in Appendices C-E should help in understanding and applying classification systems to a particular area.

Appendix C
Definition Crosswalk
(Vegetation Classification Terms)

Major terms are given with the applicable reference shown in parentheses. Terms having similar definitions are indented and given below with their applicable reference shown in parentheses.

Association (4,5,6,9)	In normal usage, this is a climax community type or potential natural community. In riparian systems, because of their dynamic nature, a true climax community may not have an opportunity to occur (Youngblood et al. 1985). An association for a riparian environment is therefore a plant community type representing the latest successional stage attainable on a specific hydrologically influenced surface (Kovalchik 1987, Hansen 1989).Hansen (1989) uses the term "riparian association" while Youngblood et al. (1985) chose the term "potential stable community type" that approaches an association.
Community Type (1,4,5,6,7,9) Association (2)	All sites in which the dominant and/or indicator species are similar. The aggregation of all plant communities distinguished by floristic and structural similarities in both overstory and undergrowth layers. The method in which community types are determined varies between procedure. Generally some type of statistical procedure is applied to composition or structural data that has been collected through a stratified mapping procedure. The discreetness of the mapping unit reflects the complexity of representative community type. In procedure (7), Platts et al. (1988) has a unit called a complex which may contain several community types that appear to be associated to similar riverine sequences. Community type names are generally determined from the name of the dominant or codominant species. Also, Dick-Peddie and Hubbard (1977) stress the importance of using obligate riparian species when determining the dominant species. This convention, however, is not specifically stated in all of the riparian classification procedures.
Dominant Species (1,2,3,4,5,6,7,9,10)	Those species in a stand that have the greatest foliar canopy volume per unit area (9). Those species with at least 25 percent [30 percent in (10)] canopy coverage in the tallest layer of a site (5). Therefore, the method by which dominant species is collected should be known. Also, Dick-Peddie and Hubbard (1977) stress the importance of using obligate riparian species when determining the dominant species. This convention, however, is not specifically stated in all of the riparian classification procedures.

Ecological Site (1,6) Range Site (1) Site Type (9) Riparian Site Type (5) Riverine Site (7) Riparian Site (7)	A distinctive type of land that differs from other kinds of land in its ability to produce a characteristic potential natural community. (This definition has been modified to not limit the natural community to just plants.) For example, as used in (7), a riverine site would be similar to the above but would produce a characteristic natural stream community.
Potential Natural Community (1,9) Climax Community(1)	The biotic community that would become established if all successional sequences were completed without interferences by man under the present environmental conditions. Often, the potential natural community of a site has to be estimated, since most managed sites support seral plant communities due to ongoing disturbance. Climax plant community as defined in (9) is the culminating stage in plant succession for a given environment that develops and perpetuates itself in the absence of disturbance (see habitat type).
Habitat Type (4, 5, 9)	All the land capable of producing similar communities at climax. A habitat type name incorporates those indicator plant species which best define the environment to be classified. A habitat type may or may not be synonymous with a range site/ecological site; most often it is a somewhat broader classification than the range site.

Appendix D
Stream Classification - Wetland and Deepwater Habitats (10) Compared to Rosgen, 1985

Riverine (10, 7, 6, 5)	Habitats contained within a channel and/or wetland (assuming also riparian) habitats dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens and habitats with water containing ocean-derived salts in excess of 0.5 parts per thousand (10). [This definition generally fits well with (7).]
Tidal (10)	Low gradient with water velocity under tidal influence. Streambed is mainly mud with occasional patches of sand (10). Would be similar to a Rosgen C4, C5, C6, F4, F5.
Lower Perennial (10)	Low gradient, low velocity water, no tidal influence with water flowing throughout the year. Substrates consists mainly of sand and mud (10). Would be similar to Rosgen C4, C5, C6, F4, F5.
Upper Perennial (10)	High gradient, high velocity. The substrate consists of rock, cobbles, or gravel with occasional patches of sand (10). Similar to Rosgen A and B stream types.
Intermittent (10)	The channel contains nontidal flowing water for only part of the year. When the water is not flowing, it may remain in pools or surface water may be absent (10). (This definition would also include ephemeral streams, those that only flow in response to precipitation.)

Appendix E
Classification of Wetland and Deepwater Habitats(10) Compared to Other Procedures (at the Class and Subclass Levels)

Class, Subclass (10)	The class is the general appearance of the habitat in terms of either the dominant life form of the vegetation or the physiography and composition of the substrate. Subclasses are used for finer differentiation.
Emergent	Characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens (10). Named marshland in (2).
	Emergent/saturated/organic soil is equivalent to fen (3, 10). In (3), this includes: Atlantic ribbed fen, basin fen, channel fen, collapse scar fen, feather fen, floating fen, horizontal fen, ladder fen, lowland polygon fen, net fen, northern ribbed fen, palsa fen, shore fen, slope fen, snowpatch fen, spring fen, and stream fen.
	An emergent/saturated/Palustrine area in (10) would be called herbaceous in (8).
	Emergent/saturated, fresh water/mineral soil is equivalent to marsh, fresh water in (8), or in (3), a subclass could be tidal fresh water marsh, floodplain marsh, stream marsh, channel marsh, active delta marsh, inactive delta marsh, terminal basin marsh, shallow basin marsh, k- narsh, seepage track marsh, and shore marsh.
	Emergent/saturated/mixosaline/mineral soil is equivalent to marsh, saline water in (8) or estuarine high marsh, estuarine low marsh, coastal high marsh, and coastal low marsh in (3).
Moss-Lichen	A saturated regime where mosses or lichens cover substrate other than rock and where emergents, shrubs, or trees make up less than 30 percent of the areal cover (10). Called a bog in (8). In (3) this includes: Atlantic plateau bog,basin bog, blanket bog, collapse scar bog, domed bog, flat bog, floating bog, lowland polygon bog, mound bog, northern plateau bog, palsa bog, peat mound bog, peat plateau bog, polygonal peat plateau bog, shore bog, slope bog, string bog, or veneer bog.
Aquatic Bed	Wetlands and deepwater habitats dominated by plants that grow principally on or below the surface of the water for most of the growing season (10). Called floating, rooted submerged, rooted floating, rooted emergent in (8). Called floating or submerged in (3). Called submergents in (2).

Scrub-shrub	Areas dominated by woody vegetation less than 6 meters (20 feet) tall (10). Called a Swampscrub in (2); however, height is less than 12 m (35 feet). Called shrub type in (3). Scrub-shrub/saturated/organic soil is called a carr in (8). Scrub-shrub, saturated, fresh (acidic), organic soil in (10) called a shrub bog in (8). Scrub-shrub, seasonally flooded, fresh water, mineral soil in (10) called a shrub wetland, mineral soil, fresh water in (8). Scrub-shrub, seasonally flooded, hypersaline water, mineral soil in (10), called shrub wetland mineral soil, saline water in (8).
Forested	Characterized by woody vegetation that is 6 m tall or taller (20 feet) in (10). Called swampforest or riparian forest if taller than 35 feet, (12 m) in (2), treed in (3), coniferous or deciduous angiosperm forest in (8) [which relates to the subclasses of deciduous or evergreen in (10)].
Streambed	Wetlands contained between channels and that are not considered permanently exposed to water (10). Subclasses included bedrock, rubble, cobble-gravel, sand, mud, organic, and vegetated streambeds. Called a strand in (2).
Unconsolidated Shore	All wetlands having unconsolidated substrates with less than 75 percent areal cover of stones, boulders, or bedrock; less than 30 percent areal cover of vegetation other than pioneering plants; and not considered permanently covered by water throughout the growing season [see (10) for exact water regime definitions]. Subclasses include cobble-gravel, sand, mud, organic, and vegetated. Called a strand in (2).
Rock Bottom	All wetlands having an areal cover of stones, boulders, or bedrock 75 percent or greater (25 percent or greater for unconsolidated bottom), vegetative cover less than 30 percent, and are generally covered throughout the growing season with water.

Appendix F
Processes and Associated Factors Controlling Riparian Function

Moisture/Inundation

Discharge	Climate/weather, watershed roughness/detention, slope.
Stage/Inundation/ Velocity	Discharge, channel geometry, energy dissipation (hydraulic controls, channel/flood plain roughness), hydraulic gradient.
Flood Plain Recharge	Substrate texture and configuration, stage/inundation (depth, extent, duration), vegetation.
Flood Plain Storage and Release	Substrate texture and configuration, flood plain recharge.
Saturated Surface	Recharge, substrate texture and configuration, hydraulic gradient.
Capillarity	Substrate texture and configuration, saturated surface.
Evapotranspiration Vegetation	Shading and wind, capillarity.

Physical and Chemical Water Quality

Aerobic State	Substrate texture and configuration, hydraulic gradient, vegetation density.
Salt Flux (flood plain)	Dissolved solids in saturated surface, capillarity, evapotranspiration, flood plain recharge.
Nutrient Flux	Transport/deposition, capillarity, recharge, evapotranspiration, biological processes.
Material Flux	Transport/deposition, vegetation, substrate texture, discharge.
Cation Exchange	Substrate texture and composition, vegetation.
Shading, Wind	Vegetation, geomorphology, topography.
Biologic Input/Release	Temperature, organisms, water chemistry.

Transport/Deposition

Degradation/Aggradation	Substrate, slope, stage, vegetation.
General Material	Availability of material, protection removal/transport (armoring), filtration, adsorption, stage (velocity).
Ice	Temperature, geomorphology, stage, velocity.

Geomorphology/Channel Geometry

Channel Cross-Section	Substrate texture and configuration, discharge, transport/ deposition.
Sinuosity	Substrate texture and configuration, discharge, transport/ deposition, hydraulic gradient.
Ice	Weather, stage/inundation/velocity, substrate.

Recruitment/Reproduction

Seed, Sprout	Transport/deposition, substrate texture, moisture/inundation.

Survival

Moisture	Moisture/inundation.
Nutrients, Water Quality	Physical/chemical water quality, transport/deposition.
Solar	Shading.
Disturbance Factors	Stage/inundation/velocity, moisture factors, aerobic state, salt flux, shading, aggradation/degradation, material transport,ice, community dynamics (competition).

Community Dynamics

Community dynamics incorporates all of the reproduction/recruitment and survival factors.

*U.S. Government Printing Office: 1991 — 573-003/22005